Nosologic imaging of the brain: combined MRI and MRSI segmentation and classification

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Introduction – In [1] the use of nosological images was introduced. A nosologic image summarizes the existence of different tissues in a single image which makes it easy to interpret for clinicians. Each voxel or pixel of the image is coloured according to the histopathological class it belongs to. In [1] and [2] MRI was combined with MRSI information to create nosological images. However, each voxel or pixel was treated independently, not including any spatial information. To exploit neighbourhood information in MRSI, canonical correlation analysis was proposed in [3]. In the present study we apply more advanced methods from image processing and pattern recognition to segment and classify brain tumours, thereby including spatial information. MRSI and MRI data are combined to produce higher resolution nosologic images. Furthermore, class probabilities are calculated for the segmented tumour region.

Materials and methods – From the INTERPRET database MRSI and MRI data from 25 patients and 4 volunteers (acquired at the RU Nijmegen Medical Centre), which were validated by histopathology, are selected. To create a training set for the pattern recognition methods 10 peak integrated values for each of the 681 short echo time spectra, picked from selected voxels of the MRSI, are combined with 4 image intensities. All training data are semi-automatically preprocessed as described in [2]. These training cases comprise normal tissue, CSF, grade II gliomas, grade III gliomas, meningiomas and glioblastomas. In the first step segmentation is performed, based on the framework established in [4], utilizing T1, T2, Pd and Gd enhanced images. As a prior for segmentation, a digital brain atlas is used. This framework is extended by modifying the prior thereby incorporating the presence of tumour tissue, calculated from the MRSI, as well. In the next step classification of the tumour region is done based on MRI and MRSI. Diverse classification methods are included: canonical correlation analysis (CCA), Bayesian least squares support vector machines (LS-SVMs) using pairwise coupling [5] and multiclass kernel logistic regression [6].

Results and conclusion – A leave-one-patient-out evaluation analysis is performed in this study. The segmentation and classification scheme are first applied to a patient with a grade III glioma tumour (Fig. 1), next, to patients with a grade II glioma tumour and a glioblastoma tumour (Fig. 2). For classification purposes, CCA and Bayesian LS-SVMs in combination with pairwise coupling have been used. In the nosologic image light blue reflects white matter, dark blue gray matter, green CSF, yellow grade II glioma, orange grade III and brown glioblastoma. Also, for the first patient, class probabilities of grade III glioma are provided for the segmented tumour based on multiclass kernel logistic regression. The lighter the map is, the higher the probability for grade III glioma. The proposed scheme benefits from both advanced image processing methods, producing an improved segmented image, and sophisticated classification methods from pattern recognition. The combined scheme offers a new way to produce nosologic images, representing tumour heterogeneity and class probabilities, which may help clinicians in decision making.

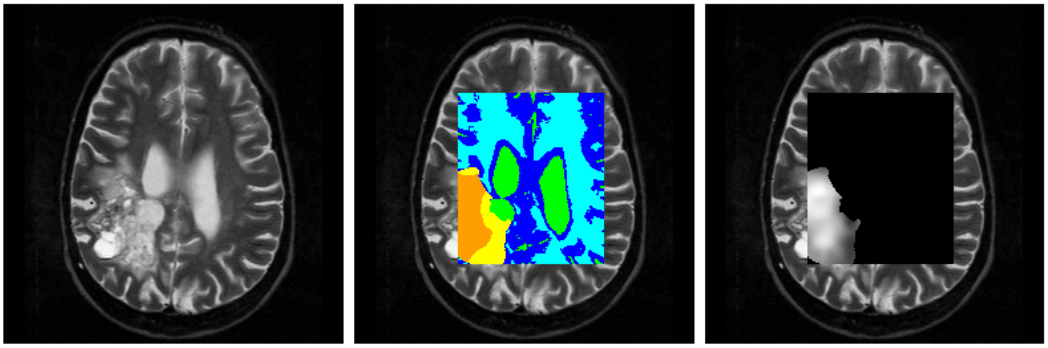

Figure 1: T2 image of a patient with a grade III glioma tumour. The nosologic image indicates a grade III region and grade II region near the border of the tumour. On the right a map is provided with the probabilities for grade III glioma tissue within the segmented tumour.

References – [1] F.S. De Edelenyi et al., Nat Med 6 (2000), pp. 1287-1289; [2] A.W. Simonetti et al., Anal Chem 75 (2003), pp. 5352-5361; [3] T. Laudadio et al., Magn Reson Med 54 (2005), pp. 1519-1529; [4] M. Prastawa et al., Med Image Anal 8 (2004), pp. 275-283; [5] J. Luts et al., Artif Intell Med 40 (2007), pp. 87-102; [6] P. Karsmakers et al., IJCNN (2007).

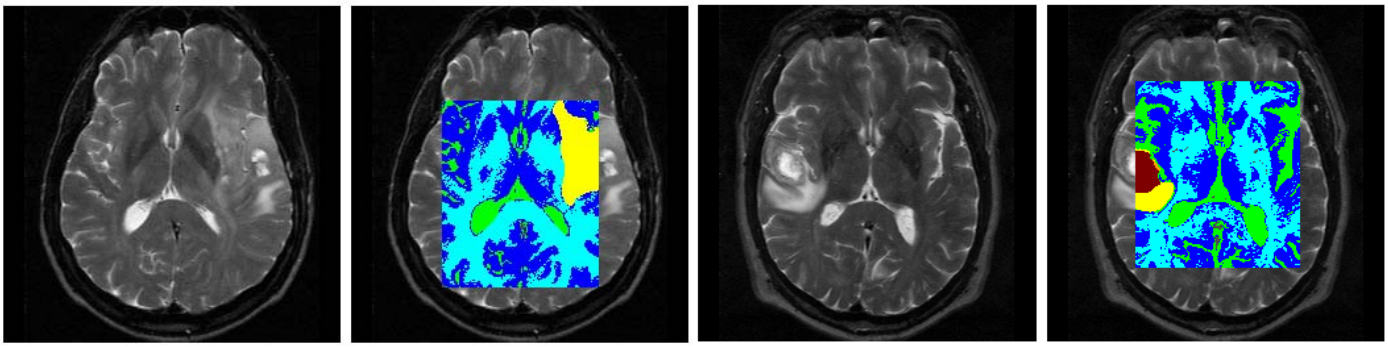

Figure 2: T2 image and nosologic image for a patient with a grade II glioma tumour and a patient with a glioblastoma tumour. For the patient with the glioblastoma tumour, also grade II tissue is detected.